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Studies on Vegetation and Soil Characteristics of Karachi University Campus

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Abstract

A survey of vegetation of Karachi University was conducted. Total numbers of nineteen species were recorded. Aeluropus lagopoides (Linn.) Trin. attained the highest importance value index (260.50) followed by Suaeda fruticosa (L.) 228.93, Zygophyllum simplex (L.) 223.15, Prosopis juliflora (Swartz) DC. 194.54, Salvia sentolinifolia L. 148.46 and Calotropis procera (Willd) 137. 95. Whereas, Digera muricata (L.) Mart attained the moderate importance value index 81.47. Senna holosericea (L.) attained further lower importance value index 27.34. P. juliflora attained the leading presence class IV. Four species viz. Aeluropus lagopoides, S. fruticosa, Z. simplex and A. javanica attained Class II. Whereas, fourteen species, A. fruticosum, C. trilocularis, S. holosericea, T. amplexicaule, C. depressus, T. terrestis, F. indica, A. aspera, H. europium, S. baryosma, S. sentolinifolia, C. procera and D. muricata attained presence class I.

The physical and chemical soil characteristics of the campus area were related with the vegetation of the areas. The campus area soil was alkaline in nature. The physical properties of Campus soil such as Maximum Water Holding Capacity (23.50 – 41.00 %), bulk density (1.30 – 1.60 g/cc) and porosity (40.60 – 47.60 %) were recorded. Chemical properties of soil for total dissolved salts (0.50 – 1.90 %), extractable sodium (150 - 3100 μg^{-g}), extractable potassium (160 – 310 μg^{-g}), calcium carbonate (4.10 – 27.10 %), electrical conductivity of soil (0.80 - 2.80 mS cm^{-1}), available sulphur (8.45 – 73.0 μg^{-g}) and chloride (3.60 – 397.50 Meq. l^{-1}) were determined.

Keywords: Halophytes; Importance Value Index (I.V.I); Plant communities; Soil characteristics; Xerophytes.

1. Introduction

The subject of vegetation description and classification is diverse and complex in nature. Vegetation may be regarded as being composed of all different types of plant communities. Grisebach (1872) recognized group of plants or communities as a unit of study and described the vegetation on this basis. The structure of plant communities is the outcome of the habitat and environmental conditions including biotic and abiotic stresses. Since soil and biotic factors are related to each other, change in anyone of these components might cause a change in other associated components (Malik et al., 2007).

The vegetation of the urban areas has been found disturbed due to various types of anthropogenic activities. High intense disturbances also sometimes threaten the survival of some species and yield to low richness (Barbara, 2003). The phytosociological studies around Karachi had been carried out by few workers in past (Chaudhry, 1961; Shaukat and Qadir, 1970; Iqbal and Qadir, 1974; Ahmed et al., 1978; Shaukat et al., 1981; Shafiq and Iqbal, 1987, 1988; Shafiq et al., 1992; Zaman and Iqbal, 1994). Sand dunes vegetation of coastal regions of Karachi was observed (Chaudhry and Qadir, 1958). Phytosociological studies around the polluted disposal channel of industrial areas of Karachi were carried out (Iqbal et al., 1983). A phytosociological survey of the Karachi University Campus in early sixties was carried out by (Qadir et al., 1966). Plant communities on the sandy areas of Karachi, University Campus were also studied (Iqbal and Shafiq, 1996). An ecological survey of certain plant communities was carried out to provide quantitative description of the vegetation on the disturbed areas of the Karachi city (Pakistan), which is changing from natural to semi-natural form due to anthropogenic disturbances, which are still in progress (Iqbal et al., 2008). The communities were reported distinct types ranging from halophytes to xerophytes with disturbed in nature.

Soil is an important component of the earth's biosphere (Glanz, 1995). The plants under stress conditions are most likely to be adversely affected by under lying factors. Changes in edpahic character usually caused changes the association of plant species and composition of plant communities. Below ground soil characteristics are recognized as possible key factors in affecting plant species coexistence and community organization (Bonanomi and Mazzoleni, 2005). Bulk

density is an indicator of soil compaction. It is calculated as the dry weight of soil divided by its volume. This volume includes the volume of soil particles and the volume of pores among soil typically expressed in g/cm^3 (USDA, 2008). It is well known that soil bulk density and strength are important factors affecting both shoot and root growth of plants (Goodman and Ennos, 1999). Porosity is defined as the ratio of the volume of voids to the total volume of the material Soil is a critical component in the germination, growth and survival of plants. Sunlight, nutrients and fresh water are essential to plant life, and the soil type can govern the availability of both nutrients and fresh water (Martonas, 2012). Plant communities are affected by physical and chemical properties of soil. The objective of the present study was to investigate the vegetation and edaphic characteristics of the University Campus. This was achieved by sampling of species and collecting the soil samples from different sites of the campus.

2. Materials and Methods

The city of Karachi is located on semi arid zone at 64^o longitude and 27^o latitude on the shores of the Arabian Sea with moderate climate. May and June are the hottest months of the year with temperature as high as 43 ºC while January is the coldest month with temperature as low as 5 ºC. Rain in Karachi is seasonal, averaging less than 22 cm per year between June and September and rare for the reminder of the year. Occasionally, there are dry year too while strong coastal winds and better dew formation are the characteristics feature of Karachi (Iqbal and Shafiq, 1996). The ever growing high rates of population growth and construction of new structure on the campus of University of Karachi has been observed as compared to last couple of decades. The University of Karachi is a public University located in Karachi. It serves an on-campus student population of more than 24,000. The University Campus is spread over 1,279 acres (5.18 km^2) of land, situated 12 km away from the city center of Karachi (Wikipedia, 2012). The vegetation and soil sampling was carried out at disturbed sites of the University campus viz. A= Abid General Store, B= E-Type Football Ground, C= D-Types Houses, D= Graveyard, and E= Staff Colony Gate.

2.1 Vegetation Sampling

A Phytosociological survey was conducted in five different areas of Karachi University Campus during the mid November to early December, 2010 by Point Centered Quarter Method (PCQM) of Cottom and Curtis (1956). Five different sites were surveyed in University campus areas. Density, frequency, relative cover was calculated and important Value Index (IVI) was obtained by addition of these community attributes. The community was named according to first dominant species. In our study equal spaced sample points were positioned through the study area. Each sample point was then divided into quarters and, in each, the distance and species name of the individual closest to the samples points were recorded.

2.2 Soil Sample Collection

Soil samples were taken from five different dominant plant communities at 45 cm depth. These samples were brought to the laboratory in polythene bags and were in air for dried. The soil samples were passed through 2 mm sieve after drying. Maximum Water Holding Capacity (M.W.H.C.) of soil was determined by the method of Keen (1931). Bulk density of soil was found according to Birkeland (1984). Calcium carbonate was determined by a method of acid neutralization, which was described by Qadir et al., (1966). Soil pH was determined by direct pH reading meter (Mettler Toledo, MP 220). Chlorides were determined through titration by Mohr's Method. Soil sulfur as available sulfate in soil was determined by turbidity method as described by Iqbal (1988). Exchangeable sodium and potassium in soil was determined according to Richards (1954). Soil Electrical Conductivity (EC) and Total Dissolved salts were determined by AGB 1000 (England) conductivity reading meter. All the data was statistically analysed by Analysis of Variance (ANOVA) and Duncan's Multiple Range Test (D.M.R.T.) at $p<0.05$ using personnel computer with software COSTAT version 3.

3. Results

A phytosociological survey at different sites of Karachi University Campus was conducted (Table 1). Five plant communities were established on the basis of first three dominant species in stand. The plant species found in the area are summarized in Table 2. Aeluropus lagopoides (Linn.) Trin. attained the highest importance value index (260.50) followed by Suaeda fruticosa (L.) 228.93, Zygophyllum simplex (L.) 223.15, Prosopis juliflora (Swartz) DC. 194.54, Salvia sentolinifolia L. 148.46 and Calotropis procera (Willd) 137.95. Whereas, Digera muricata (L.) Mart attained the moderate importance value indices 81.47 followed by Aerva javanica (Burm. f.) 43.22, Abutilon fruticosum (L.) 36.76 and Corchorus trilocularis (L.) 33.15. Senna holosericea (L.) attained the lower importance value index 27.34 followed by Trichodesma amplexicaule Roth. 24.84, Crochorus depressus (L.) 23.95, Tribulus terrestis (L.) 23.01, Fagonia indica Burm. F. 22.25, Achyranthes aspera Linn 17.45, Heliotropium europaeum Linn 10.27, Salsola baryosma (Schult.) Dandy 9.72 and Heliotropium ramosissimum (Lehm.) DC. 7.18, respectively. P. juliflora attained the leading presence class IV. Four species viz. Aeluropus sp, S. fruticosa, Z. simplex and A. javanica attained Class II. Whereas, the remaining fourteen species attained Class I. The community descriptions in relation to soil characteristics are described as follows (Table 3):

1. **Suaeda – Aeluropus - Prosopis community**: S. fruticosa in occurs two time as a first leading dominant species. This community formed an association with A. lagopoides and P. juliflora which preferred to grow on better water holding capacity of soil (39.50 %), low bulk density (1.30 g cm^{-3}) with high percentage of soil porosity (43.70 %). This community preferred to grow on highest percentage of total dissolved salts (1.90 %), soluble sodium (12400 μg^{-g}), Extractable sodium (3100 μg^{-g}), soluble potassium (110 μg^{-g}), Phosphorous (24.20 μg^{-g}) and EC (2.80 mS cm^{-1}). The moderate level of Extractable potassium (180 μg^{-g}) was recorded. A better percentage of $CaCO_3$ (10.0 %), available sulphur (44.0 µg g^{-1}) and chlorides (397.50 Meq. l^{-1}) and the lowest level of soil pH (7.30) was recorded in this community.

2. **Suaeda – Aeluropus community.** S. fruticosa in occurs two time as a first leading dominant species. This community formed an association with A. lagopoides. Soil characteristics of this community indicated that the community is well growing with moderate percentage of maximum water holding capacity (37.50 %) of soil, bulk density (1.40 g cm^{-3}) and porosity (44.50 %). The community soil contain better amount of total dissolved salts (0.65 %), extractable sodium (1050 μg^{-g}) and EC (0.95 mS cm^{-1}). An appreciable percentage of $CaCO_3$ (16.60 %), available sulphur (8.50 µg g^{-1}), chlorides (87.30 Meq. l^{-1}) and the soil pH (7.50) was determined in this community.

3. **Salvia - Corchorus - Senna community.** Salvia community formed an association with C. depressus and S. holoserecea. This community preferred to grow on better water holding capacity of soil (41.00 %), bulk density (1.40 g cm^{-3}) and soil porosity (45.80 %). This community preferred to grow on moderate percentage of total dissolved salts (0.60 %), extractable sodium (490 μg^{-g}) and EC (0.90 mS cm^{-1}). The moderate level of Extractable potassium (300 μg^{-g}) was also recorded. A better percentage of $CaCO_3$ (18.10 %), available sulphur (23.50 µg g^{-1}) and chlorides (50.90 Meq. l^{-1}) and the soil pH was (7.60).

4. **Zygophyllum - Abutilon - Salvia community.** Z. simplex occurred one time as first leading dominant in stand. Zygophyllum community formed an association with A. fruticosum and S. sentolinifolia. This community is supported by highest value of bulk density (1.60 g cm^{-3}) with lowest water holding capacity of soil (23.50%) and better soil porosity (40.60 %). This community preferred to grow on highest percentage of Calcium carbonate (27.10 %) and available sulphur (73.0 µg g^{-1}). This community also preferred to grow on better percentage of total dissolved salts (1.35 %), extractable sodium (1600 μg^{-g}) and electrical conductivity (2.05 mS cm^{-1}). The moderate level of extractable potassium (170 μg^{-g}) and soil pH (7.40) was recorded.

5. **Calotropis - Trichodesma - Tribulus community:** C. procera occurred one time as a first leading dominant. Calotropis community formed an association with T. amplexicaule and T. teristris. This community is supported by slightly higher value of bulk density (1.50 g cm^{-3}), water holding capacity of soil (33.00 %) and soil porosity (43.10 %). This community also preferred to grow on lowest percentage of calcium carbonate (4.10 %), total dissolved salts (0.50 %), extractable sodium (150 μg^{-g}) and extractable potassium (160 μg^{-g}). A better level of available sulphur (27.00 µg g^{-1}) was recorded. This community also preferred to grow at 0.80 mS cm^{-1}) soil electrical conductivity. The moderate level of chlorides (3.60 Meq. l^{-1}) was the characteristic feature of this community soil while, the high level of soil pH (8.0) was recorded in this community.

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Table 1: Phytosociological characteristics of the study area

S. No.	Name of Plant Species	Presence class	Importance value index				No of stands dominant		
			Total	Max.	Min.	Mean	Ist	2nd	3rd
1	Aeluropus lagopoides (Linn.) Trin.	II	260.50	201.08	58.70	130.25	-	2	-
2	Suaeda fruticosa (L.) Forsk.	II	228.93	196.90	32.74	114.46	2	-	-
3	Zygophyllum simplex (L.)	II	223.15	119.14	24.01	111.27	1	-	-
4	Prosopis juliflora (Swartz) DC.	IV	194.54	98.60	20.26	48.63	-	-	1
5	Salvia sentolinifolia L.	I	148.46	148.46	148.46	148.46	1	-	1
6	Calotropis procera (Willd)	I	137.95	137.95	137.95	137.95	1	-	-
7	Digera muricata (L.) Mart	I	81.47	81.47	81.47	81.47	-	-	-
8	Aerva javanica (Burm. f.)	II	43.22	22.69	20.53	21.61	-	-	-
9	Abutilon fruticosum. (L.)	I	36.76	36.76	36.76	36.76	-	1	-
10	Corchorus trilocularis (L.)	I	33.15	33.15	33.15	33.15	-	1	-
11	Senna holosericea (L.)	I	27.34	27.34	27.34	27.34	-	-	1
12	Trichodesma amplexicaule Roth.	I	24.84	24.84	24.84	24.84	-	1	-
13	Crochorus depressus (L.)	I	23.95	23.95	23.95	23.95	-	-	
14	Tribulus terrestis L.	I	23.01	23.01	23.01	23.01	-	-	1
15	Fagonia indica Burm. F.	I	22.25	22.25	22.25	22.25	-	-	-
16	Achyranthes aspera Linn	I	17.45	17.45	17.45	17.45	-	-	-
17	Heliotropium europaeum L.	I	10.27	10.27	10.27	10.27	-	-	-
18	Salsola baryosma (Schult.) Dandy.	I	9.72	9.72	9.72	9.72	-	-	-
19	Heliotropium ramosissimum (Lehm.) DC.	I	7.18	7.18	7.18	7.18	-	-	-
	Symbol Used: IVI: Importance Value Index								

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Table 2: Leading dominant species of the study area

Number of stands	Ist dominant	2nd dominant	3rd dominant
1	Suaeda fruticosa (L.) Forsk.	Aeluropus lagopoides (L.) Trin	Prosopis juliflora (Swartz) DC.
2	Suaeda fruticosa (L.) Forsk.	Aeluropus lagopoides (L.) Trin	-
3	Salvia sentolinifolia L.	Corchorus trilocularis (L.)	Senna holosericea (L.)
4	Zygophyllum simplex (L.)	Abutilon fruticosum. (L.)	Salvia sentolinifolia L.
5	Calotropis procera (Willd)	Trichodesma amplexicaule Roth.	Tribulus terrestis L.

Table 3: Physical and chemical properties of Campus area soil

	PLANT COMMUNITIES				
Soil characteristics	Suaeda – Aeluropus – Prosopis	Suaeda – Aeluropus	Salvia - Corchorus - Senna	Zygophyllum - Abutilon – Salvia	Calotropis - Trichodesma – Tribulus
M.W.H.C. (%)	39.50 c ±0.50	37.50 bc ± 0.04	41.00 c ± 3.0	23.50 a ± 1.50	33.00 b ± 0.01
B.D. (g cm^{-3})	1.30 a ± 0.05	1.40 ab ± 0.02	1.40 ab ± 0.01	1.60 d ± 0.02	1.50 bc ± 0.02
Porosity (%)	47.60 d ±0.40	44.50 bc ±0.50	45.80 cd ± 0.15	40.60 a ± 1.30	42.10 abc ± 0.85
T.D.S. (%)	1.90 e ±0.0	0.65 b ± 0.0	0.60b ± 0.0	1.35d ± .05	0.50 a ± 0.0
Ext. Na (μg^{-g})	3100.00 e ± 200	1050.00 c ± 70	490.00 a ± 50	1600.00 d ± 160	150.00 a ± 0.0
Ext. K (μg^{-g})	180.00 a ± 0.0	310.00 b ± 10	300.00 b ± 20	170.00 a ± 10	160.00 a ± 0.0
$CaCO_3$ (%)	10.0 b ± 0.10	16.60 c ± 0.60	18.10 c ± 0.20	27.10 e ± 1.10	4.10 a ± 0.30
EC (mS cm^{-1})	2.80 e ± 0.05	0.95 c ± 0.0	0.90 bc ± 0.05	2.05 d ± 0.0	0.80 b ± 0.0
pH	7.30 a ± 0.05	7.50 b ± 0.03	7.60 b ± 0.07	7.40 ab ± 0.06	8.00 c ± 0.00
S ($\mu g g^{-1}$)	44.0 d ± 1.50	8.50 a ± 0.50	23.50 b ± 1.50	73.00 e ± 0.00	27.00 c ± 0.00
Cl Meq. l^{-1}	397.50 e ± 2.40	87.30 e ± 0.06	50.90 b ± 1.0	307.00d ± 0.05	3.60 a ± 0.30

Symbol used: TDS = Total dissolved salts; Ext. Na = Extractable sodium ; Ext. K= Extractable potassium; EC= Electrical conductivity; S = Available sulphur; Cl= Chlorides; $CaCO_3$= Calcium carbonate. Statistical significance determined by analysis of variance. Number followed by the same letter in the same column are not significantly different, according to Duncan's Multiple range test at $P<0.05$.

4. Discussion

The plant communities at different sites of Karachi University Campus are found with diverse group of plant species. In present studies the nature, structure and composition of plant communities in recent years at the campus site was found disturbed due to various types of anthropogenic activities, construction of new structure and changes in the immediate environment. Similar observations were found by other research workers in various other parts of the country on the phytosociological studies of Quaid-e-Azam University Campus, Islamabad (Akbar and Ahmed, 1991) and in sandy areas of University of Karachi, campus (Iqbal and shafiq, 1996). The resilience of plant communities to disturbance can be characterized by the ability of species and life-forms to recover, provided that the desired degree of naturalness is present (Hylgaard, 1980). The present quantitative studies reveals that the composition of the vegetation was dominated by halophytes, xerophytes and disturbed types of species viz. S. fruticosa, P. juliflora, A. lagopoides, S. sentolinifolia, Z. simplex, S. holoserecea and A. javanica. Among all the listed species, S. fruticosa attained the highest Importance Value Index (IVI). Since importance value index showed the relative ecological importance of each species in the stands

(Brown and Curtis, 1957). A. lagopoides is a perennial grass distributed from coastal Sind and Balouchistan to saline flats of Punjab, Pakistan (Gulzar and Khan, 2001). In a study the vegetation survey of Umm as Sami is a vast salt flat of central Oman was found dominated by A. lagopoides and Tetraena qatarensis and concluded that both species are widely distributed in arid regions. A. lagopoides stretches from the Mediterranean to the Indian subcontinent with presence in all countries of the Arab peninsula (König, 2012).

The distribution, pattern and abundance of plant species and communities in desert environments has most often been released to three groups of factors; physical environmental variables affecting water availability, soil chemistry and anthropogenic disturbance (Enright et al., 2005). The leading of different dominant species in present studies indicates that the physical and chemical properties of soil influenced on the vegetation of the area. The leading of different dominant species in present studies also indicates that the physical and chemical properties of soil influenced on the vegetation of the area. S. fruticosa plants grown in saline conditions (200 to 40 mol m^{-3} NaCl) had greater fresh and dry weights than those grown in non-saline controls, and 600 to 1000 mol m^{-3} NaCl inhibited growth (Khan et al., 2000). S. fruticosa is an edible and medicinal halophyte (Queslati, et al., 2012). The genus Suaeda is generally considered halophytes (Kayani et al., 1984) due to the saline desert conditions. High salinity could cause the dominance of halophytes. Iqbal et al., (1983) recorded Suaeda community as a dominant near the industrial polluted channel of Karachi. S. fruticosa occurred two times as a leading first dominant species and formed an association with A. lagopoides and P. juliflora. This community preferred to grow on highest percentage of total dissolved salts, soluble sodium and electrical conductivity of soil. Chemical balance of inorganic elements in the living organism is a basic condition for proper growth and development of plants. Salt stress imposes a major environmental threat to agriculture by limiting plant growth and reducing crop yield (Pandolfi et al., 2012). S. sentolinifolia occurred one time as first dominant and one time as a third leading dominant in stands. S. sentolinifolia formed an association with C. depressus and S. holoserecea. This community preferred to grow on better water holding capacity of soil, bulk density and soil porosity. This community is supported by moderate percentage of total dissolved salts, soluble sodium, extractable sodium, soluble potassium, Phosphorous and electrical conductivity of soil. Since plants are not able to move in order to acquire resources, they respond of adapt to the environment (Climate or soil) in differing patterns of vegetative and reproductive growth (Silvertown and Rabinowitz, 1985). Salvia sentolinifolia attained third position in a stand due to highest value of bulk density with lowest water holding capacity of soil and soil porosity. Beside other factors which are responsible for plant growth, physical properties of soil such as soil strength, bulk density, texture and structure influence greatly on the root penetration, growth and yield of various crops (Gerard et al., 1982). Plant nutrient availability their fixation and downward movement with water depend one or other way on the physical properties of the soil (Sial, 1991). The soil of the study area showed difference in their physical as well as chemical characteristics. An appreciable amount of calcium carbonate, poor amount of organic matter is a characteristics feature of arid zone soils (Aubert, 1960). Plants directly depend on the soil characteristics and climatic factors for their growth and development. Singh (1986) observed that in those plant communities which had a higher percentage of soil organic matter, the water holding capacity of soil was consequently increased due to the colloidal nature of the organic matter. Zygophyllum simplex L. is a succulent annual that grows on the coastal and inland saline flats around Karachi (Khan and Ungar, 1997). Z. simplex occurred one time as first leading dominant in stand. Z. simplex formed an association with A. indicum and S. sntolinifolia in the present study. This community is supported by lowest water holding capacity of soil and soil porosity. This community also preferred to grow on highest percentage of calcium carbonate. C. procera occurred one time as a first leading dominant and formed an association with T. amplexicaule and T. teristris. This community is supported by slightly higher value of bulk density, water holding capacity of soil and soil porosity. This community preferred to grow on lowest percentage of calcium carbonate, total dissolved salts and extractable potassium as compared to Z. simplex community. (Matko, 2003). A soil's porosity and pore size distribution characterize its pore space, that portion of the soil's volume that is not occupied by or isolated by solid material. The basic character of the pore space affects and is affected by critical aspects of almost everything that occurs in the soil: the movement of water, air, and other fluids; the transport and the reaction of chemicals; and the residence of roots and other biota (Nimmo, 2004).

5. Conclusion

An intense grazing, construction of new structure and varied human impacts are changing the face of the flora and edaphic characteristics of the University Campus. It is concluded from the present findings that the ongoing activities demands the protection of the flora and immediate environment. If the haphazard population growth and the construction of new structure go on then probably there would be more vegetation changes in near future. Low IVI and changes in soil characteristics may also be warranted. The investigation suggests that revegetation of the disturbed sites might be facilitated by selection of tolerant plant species. There is a need to developed green spaces within the area for the formation of better environmental conditions for flora of the region. This study has shown that the distribution of vegetation types is more strongly related to underlying environmental factors such as physical and chemical properties of soil.

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Major focus of research is on plant ecology and environmental pollution. The research appeared in progress with publication of book, chapters in book, abstract and coupled with this, more than sixty five (65) research papers have been published in national and international peer refereed scientific journals.